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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be read in conjunction with the related student guide, includes instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a unit dealing with the human senses. Anatomy and physiology of the eyes (sight), tongue (taste), ears (hearing), nose (smell), and skin (feel/touch) are investigated. The study of these individual sense organs is then related to the structure and function of the nervous system. Parts of the brain as well as major nerves are examined during dissection of a rat. The unit concludes with simple experiments designed to establish concepts of reflex action, reflex arc, and voluntary and involuntary actions. Each section in this guide corresponds to a given section in the student study guide. (JN)

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YEAR
2



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TEACHER'S GUIDE UNIT J

Sense from Senses

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

SE 043 983

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ACKNOWLEDGEMENT: We are grateful for the considered advice we have received from the Regional Education Officers (Science) in the preparation in this unit.

OCTOBER 1983

The following symbols which appear only in the Teacher's Guide are used to indicate important points for you the teacher.



N.B.

Take note of an important point.



P

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.



We have placed this symbol next to experiments where we feel there may be a possible danger. Please read the section carefully so that you know about the particular danger in that experiment. It would also be wise to refresh your memory on the appropriate safety or first-aid procedures described in the Zim-Sci Handbook.



This symbol appears next to activities which are not experiments but involve pupils in observation and perhaps collecting information. An example is the field trip.

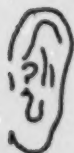
The following symbols will be used to indicate the points in the lesson at which teacher activity is particularly important. These symbols also appear at the corresponding points in the pupil study guides.



Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.



Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.



Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.



This symbol appears at a point where it is necessary for pupils to think over what they have done in the past few lessons. Set aside a period for this review activity. Encourage the pupils to read over their notes and the study guide section which they have just covered. It may be helpful to ask them to write a summary too.

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AIMS OF THIS UNIT

THE SENSES

At the end of this unit pupils should be able to:

1. identify and describe the different parts of the eye.
2. state how the thickness of a lens is related to its refracting power.
3. explain how long and short sightedness occur and which lenses would correct these defects.
4. describe the structure of the retina in terms of rods and cones and relate it to man's ability to see colour.
5. explain that sight is dependant on interpretation by the brain.
6. list the different parts of the ear and explain simply how they function and state the order in which they are arranged.
7. explain that sound is produced when vibrations occur.
8. state that sound requires a medium for transmission.
9. explain that frequency is related to length and tension of the vibrating body.
10. identify the different areas of taste on the tongue.
11. state the connection between taste and smell.
12. demonstrate that certain skin areas are more sensitive to touch, heat and cold than other areas.
13. explain the purpose of the nerves.
14. distinguish between voluntary and reflex actions.
15. describe a simple reflex arc.
16. name the main areas of the brain concerned with seeing, hearing, thinking and with voluntary and involuntary actions.

2

'THE SENSES' - Our only contact with the environment.

CONCEPT DEVELOPMENT

Following on from Unit A, children are reminded that although their senses are limited, they still remain vitally important for perceiving the environment.

The approach followed in this unit is that of investigating the various individual sense organs and building up to the nervous system.

The skin is treated as partly consisting of nerve endings of various types for detecting different types of stimulation, e.g. pressure, heat. The point is established that not all parts of the body are equally sensitive. Sensitivity depends upon the density of the nerve endings.

The tongue is realized as consisting of four major sensory areas which detect in turn, bitter taste, sour taste, sweet taste and salty taste. The connection between taste and smelling is established.

The eye - established as one of the most important sense organs.

The point is made that seeing depends upon light and that the eye cannot be successfully studied without an elementary study of the properties of light. The concept of rectilinear propagation (light travelling in straight lines) is established. Reflection is recognised as important in seeing non-luminous objects. Refraction is shown by use of lenses.

The eye's internal and external structure are investigated through the use of a bio-set and working models. The defects of vision (long and short sights) are also illustrated by the model. Experiments establish the distribution of cones and rods on the retina, the presence of a blind spot and the importance of having two eyes.

The ear is prefaced by an elementary study of sound production and propagation.

Sound is established as originating from bodies in vibratory motion and requiring a material medium. The concept of frequency or pitch is introduced and its dependence on tension and length established experimentally. There is a brief treatment of musical instruments with emphasis on African traditional instruments. A comparison with human vocal chords is made. The path of sound into the ear is traced. The sound amplifying role of the ossicles (small bones) and the frequency selective role of the nerves in the ear are illustrated.

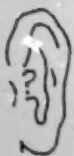
The balancing function of the ear is treated by means of a model and simple experiments. To tie all the sense organs together the nervous system is treated. Parts of the brain are studied through the dissecting of a rat. Bio-sets are used to illustrate various specialised parts of the nervous system. The concept of reflex action, reflex arc, voluntary and involuntary actions are established by simple experiments.

LONG TERM PREPARATION

It is important to prepare your work well in advance in this unit. The following are some of the things you need to plan for.

1. You will need an ox eye or goat/sheep eye by the time you get to page 23 of the Study Guide. You can ask your pupils to remember this in case some of them slaughter a beast at home. If you get the eye before or after you get to page 23, you should certainly dissect it and show your pupils right then since chances of getting another one may be slim. A butchery is another place where you might get the eye provided you speak nicely to the people there.
2. Please tell your pupils to start collecting tins about the size of their boiling tin for Experiment 10.
3. You will need to have dissected the brain and spinal cord of either a rabbit or a rat by the time you get to page 56 of the Study Guide.

P



Discussion

Page 1

Sense

Sight
Taste
Hearing
Smell
Feel/Touch

Organ

Eyes
Tongue
Ears
Nose
Skin



Experiment 1

Page 3/4

Emphasise that pupils should not prick each other hard. They may hurt each other.

The pupils will also require a ruler.

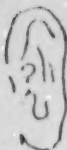
Before the experiment is carried out put on the board the following heading and table.

Heading: Are different parts of your body equally sensitive?

Table

PART OF THE BODY	DISTANCE BETWEEN THE PINS WHEN I FEEL ONE POINT
Palm Back of hand Finger tips Toes etc.	9





Discussion of questions. page 4.

Question:

What does a small distance tell you?
Does it mean the skin is very sensitive?

Answer:

Small distances indicate that that part of the skin is very sensitive. When the pupils feel one point only the two pins are on the same nerve ending. When the pupils feel two points, the two pins are on different nerve endings. If the area of the skin has a high density of nerve endings the distance will be shorter, showing high sensitivity.

Question:

Which part did you find to be most sensitive?

Answer:

This will depend upon how many other parts apart from those listed in the table the pupils will have tried. The part with the shortest distance is the most sensitive.

You cannot expect a CORRECT answer. The fingertips are one area which is highly sensitive since they have a very high number of receptors (nerve endings) per unit area. and are the most likely answer

Question:

Which part did you find to be least sensitive?

Answer:

The one with the biggest distance.

Write up of experiment. 1

Tell the pupils to write the conclusion to the heading and table which they have copied. There is no need for them to record the method.

ACTIVITY 1 : Observing sensitive cells in the skin. Page 5

It is important for your pupils to observe slide 4 and then compare it with the diagram on page 5. Notice that though slide 4 and the diagram show the same thing, slide 4 is not clear enough and the diagram shows a much clearer and more detailed structure of nerve endings. On the diagram showing the skin, one receptor is not labelled. Tell the pupils to label it "cold" receptor.



EXERCISE 1 : Matching stimuli and receptors.

Page 6.

AnswersReceptors21
22
23
24
25StimuliS
P
T
Q
REXPERIMENT 2 : Finding out which area of the tongue detects the four tastes best. Page 7.Preparation of solutions.

P

1. Bitter solution (pill solution)
 - a: Dissolve one tablet in 100ml of water.
Stir to speed the dissolving.
 - b: Give each pair of pupils about 5ml of the bitter solution.
2. Sugar solution.
 - a: Dissolve 2 teaspoons of sugar in 100ml of water.
 - b: Give about 5ml to each pair.
3. Salt solution.
 - a: Dissolve one teaspoon in 100ml of water.
 - b: Give about 5ml to each pair.
4. Vinegar (acetic acid) (sour).
 - a: Dissolve 2ml of acetic acid in 100ml of water.
You may use your 2ml measure to measure the volume of the vinegar. Sour milk can also be used (lacto type)

SAFETY:

Since children are going to be tasting the solutions, it is important that the vessels used to handle these solutions are CLEAN and SAFE.

ORGANISATION

1. You can prepare your different solutions in CLEAN and SAFE plastic cups or any other suitable vessels that you may have. Have the solutions on your table beforehand.
2. Children will have to wash their 5ml measures thoroughly. In these measures they can place the solutions collected from your table. When they have finished with one solution they should rinse its vessel before you give them the next solution.

Your children should realise that they are investigating the best tasting areas for each solution. This does not mean that other areas may not detect the taste. It is vitally important to use a very small drop in each taste area and to make sure the drop does not spread to other areas.

Heading: Areas of the tongue that detect the four tastes best

TABLE

Area of tongue	Sweet	Sour	Salt	Bitter
Back (region A)				✓
Side (region B)		✓		
Side (region C)		✓		
Front (region D)	✓		✓	

The ticks show the expected results. When you put the heading and the table on the board, LEAVE OUT THE TICKS.



ACTIVITY 2 : Observing taste buds.

Page 8

Your children should see dots on the surface of their friends' tongues. These are later identified as pimples, on the bioviewer.

Answers to Activity 2.

saliva - dissolves the food particles
 small hairs - stimulated by the food and are responsible for tasting
 nerve - carries information to the brain.



EXPERIMENT 3 : Does your sense of smell help your sense of taste?

Page 9

N.B: Make sure your children do not take this as an eating exercise.

- 1: It is important to get foods that have distinct smell and taste e.g. onion, potato crisps of various flavours.
- 2: The children should find a tastelessness in the food in their mouths when the nose is closed.
- 3: Of course, your children should have the experience of the tastelessness of food when their noses are blocked.

In this experiment your children will find out that they cannot taste well if the nose is blocked.



Answers to Exercise 2 : Tasting. Page 10.

1. The answer is smell. However, your children should copy down all the sentences as this will help them to revise.
2. See tongue diagram in Study Guide page 7 and Table in this Teachers' Guide page 6
3. Substances which are trapped in the base of the pits containing the taste buds give us an after-taste.
4. Your sense of smell affects your sense of taste. When you have a bad cold, your nostrils are blocked and so you cannot smell food.
5. There are separate receptors for light touch (such as a feather) and for a heavy touch (such as probing) on the skin.
6. It is very important. Pain is an indication that something is wrong. It is important that we are able to detect injuries and to treat them.

THE EYE Page 12

Light a candle and place it on the table in the middle of the class so that every pupil can see the light. This will help pupils to realise that light travels in ALL directions.

The top diagram shows a light ray from a candle to an eye. Make sure your pupils know this.

EXPERIMENT 4 : Changing the direction of light energy. Page 13

Ensure you have a good supply of batteries to give enough light. Pupils should switch on the light only when everything else has been assembled. Children like playing around with light and unless you warn them, your batteries are going to run down before you use them for experiments in this unit.

Since there are many small pieces in the light and eye kit it is important that your pupils know which piece is which. They need your close guidance. At the end of the experiments they should count and put safely away, everything in their proper places. One lost piece spoils the entire kit. ALLOW TIME FOR THIS.

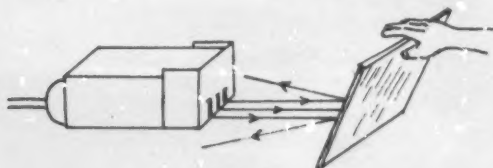
Light experiments work better in the dark or in less illuminated surroundings. If possible, the classroom should be darkened e.g by use of newspapers over the windows.

P

N.B.

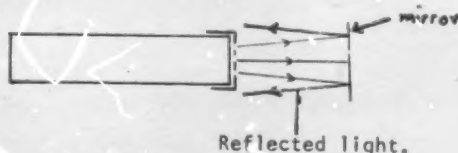
Answers to questions in Experiment 4. Page 14.

2. a: Pupils' observations as shown below.

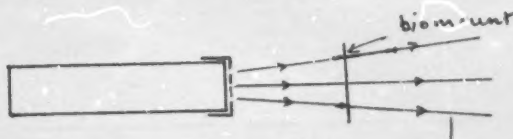


Light bounces back. It is reflected.

b: The diagram does not have to be artistic as this will waste pupils' time. Tell them to draw a simple diagram such as the one below.



c:



Transmitted light.

Discussion

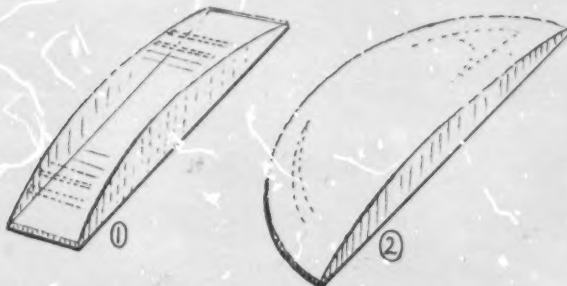
The pupils should see the direction of light being changed by the mirror. The light bounces from the mirror. Tell them that this bouncing of light is called REFLECTION. Light is being reflected by the mirror (more correctly, by the metal paint at the back of the mirror). Tell them that they see most things with the aid of the light these things reflect.

Light from a source e.g. sun, falls on objects. These objects reflect light into your eyes, then you can see them.

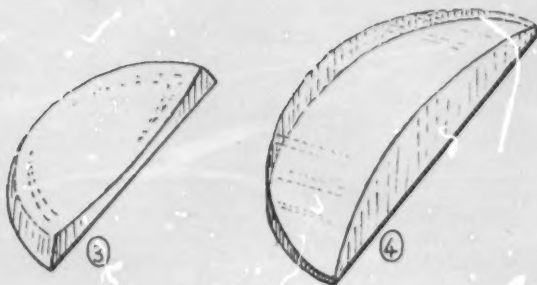
The blomount allows light to pass through it. Tell them that things that allow light to pass through are called transparent objects.

lenses Page 14.

Notice that half lenses can be combined to form full lenses.
It is possible to buy full lenses.



- Lens type 1: Convex lens from the light source box.
 Lens type 2: Convex lens from eye kit box in battery box
 (much thinner and wider than type 1).

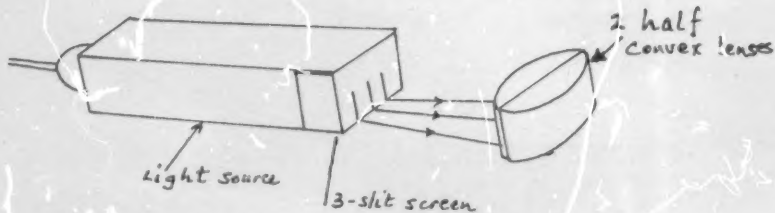


- Lens type 3: Concave lens from the eye kit in battery box
 (small, thinner in the middle and thicker at
 the end).
 Lens type 4: Convex lens from eye kit in battery box (almost
 the same size as type 1, but a bit smaller, and
 semi-circular).

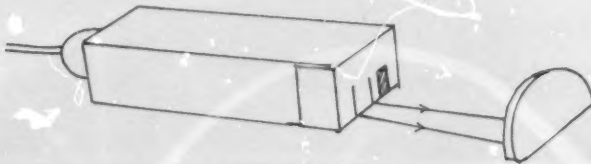
I have put together all experiments in which you are going to use
 the lenses so that you can easily refer to them. This means the
 page sequencing is not strictly chronological. I shall return
 to chronological paging later.

EXPERIMENTS IN WHICH EACH LENS IS GOING TO BE USED

Experiment 5 Page 15



In the first diagram as shown above, use type 1 of convex lenses
There are two of them.

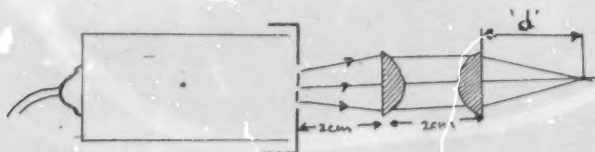


In the second diagram as shown above use type 3 concave lens.

Experiment 6 Page 17/18



instruction 2 refers to diagram above. Use lens type 1.



Instruction 3 refers to diagram above; both lenses are type 1.



Instruction 4 refers to the diagram above and the last added lens
is type 4.



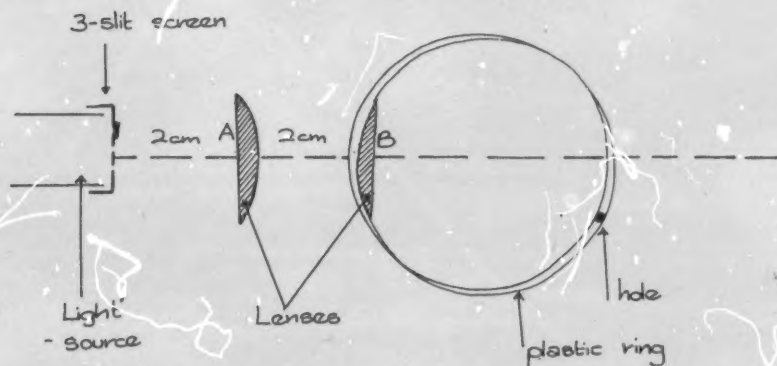
Experiment 7 Page 19



From the light source the first two lenses are type 1 and the last is type 4.

Eye Model Page 21/32

4. Place everything else as shown. In the diagram below.



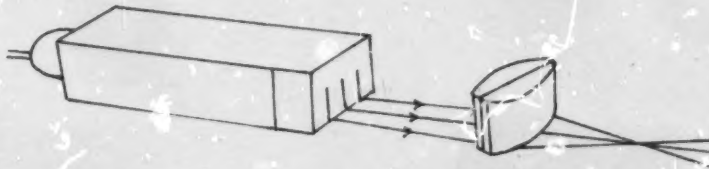
Both lenses above are type 1.



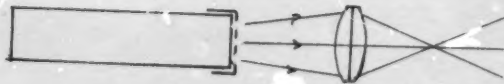
EXPERIMENT 5 : Bending light using lenses. Page 15/16

Remind your children that it is important to keep the various pieces safe.

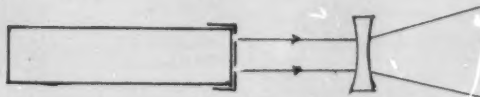
2. b. Diagram showing light after it has hit the convex lens.



OR your pupils can draw an easier section diagram, shown below.



4. b. Diagram showing light after it has hit the concave lens.



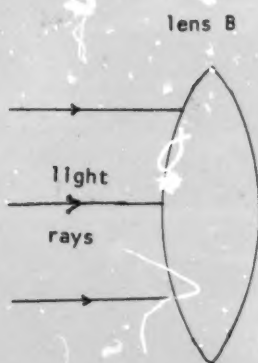
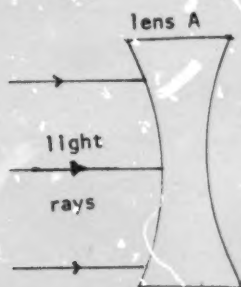
Sectional diagram.

EXERCISE 3 : Page 16.

This should now become EXERCISE 3A since there was an error made, giving two Exercise 3

Put this on the board as EXERCISE 3A : LENSES

Exercise 3A : Lenses.



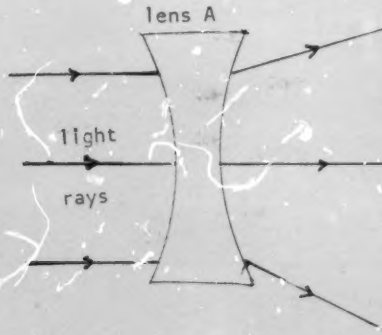
- a: What type of lens is (i) lens A?
(ii) lens B?
- b: (i) Draw the diagram of Lens A and show what happens to light rays.
(ii) Draw the diagram of lens B and show what happens to light rays.

ANSWERS TO EXERCISE 3A

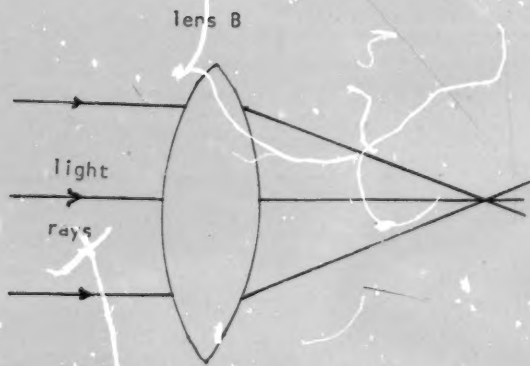
page 12

- (a) (i) Lens A is concave/diverging lens.
(ii) Lens B is convex/converging lens.

- (b) (i)



- (ii)





EXPERIMENT 6 : Changing the distance d' between the centre of the lens and the meeting point of light rays by changing lens thickness. Page 17/16

I have to keep on reminding you that children can waste batteries by switching on even when it is unnecessary. Ensure that your children are conscious of conserving energy by switching on only for a short time and only when they are ready to make suitable observations.

The lens distances in this experiment are approximated. Your children should not waste too much time trying to get the exact distances.

OBSERVATIONS:

4. a & b Your children should discover that when the lens is made thicker, the distance ' d ' becomes shorter.

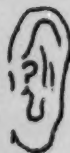


EXPERIMENT 7 : Changing distance ' d ' by changing light source distance. Page 19.

2. a & b: Your children should discover that when the light source distance is increased, the distance ' d ' increases.

DISCUSSION

Let your pupils realise that the power of the lens system to bend the light has not changed. It can only be changed by changing the thickness of the lens system. When the light source is moved away from the lenses, points at which light hits the lenses changes. This is the cause for change of distance ' d '. However, do not make a big issue out of this as it might be too difficult an idea for some pupil to understand.



EXERCISE 3 page 19/20 becomes Exercise 3B.

SINCE THERE WAS AN ERROR MADE IN ISSUING TWO Exercise 3's. Notice that the meeting point of light should be labelled G.

ANSWERS

- a: Lens E is thicker
b: Lens E is going to converge light nearer
c: Point G (the meeting point of light energy) moves further away from the lens

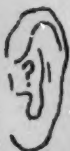




ACTIVITY 3 : Structure of the eye. Page 21

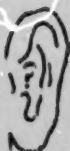
Notice there is an ear symbol missing in the Study Guide near the middle of page 21 where the text states "Discuss with your teacher!"

DISCUSSION (middle of page 21).



Your children should see that the dark areas of the eye (called the pupils) are small in bright light and big in dull light.

Tell them that light enters the eye through the dark part of the eye (the pupil) and that since very bright light can destroy the eye, in bright light the pupil becomes smaller in order to allow only a small amount of light into the eye. In dull light the pupil becomes big to allow a lot of light in so that things can be seen easily.



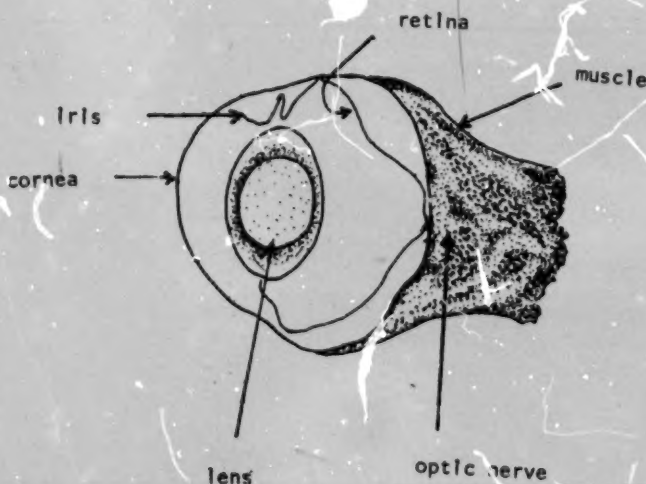
DISCUSSION (bottom of page 21)

In dull light (such as you have in the classroom) the enlargement of the pupil allows more light to get into the eyes so that things can be seen more easily.



ACTIVITY 4 : Inside (internal) structure of the eye. Page 22

The diagram should look something like this:



Answers to Question 3

- a: The structures which are transparent are:
cornea, aqueous humour, lens, and vitreous humour.
- b: Since they are transparent they allow light to pass through them and, in fact, they refract light to the retina.
- c: Since the retina is a layer of sensitive cells it is sensitive to light. It is here that you have your light receptors.
- d: Function of
i: optic nerve - carries information to the brain;
ii: Iris - made of muscle and can alter the size of the pupil to allow more or less light to get into the eye.
iii: muscle - contraction of muscle alters the size of the pupil.

DISSECTION OF THE EYE

It would be very useful to your pupils if you could dissect an eye with them. An ox eye would be ideal but if you cannot get it, try a goat's or sheep's eye. See (P) sign at the beginning of this Teacher's Guide

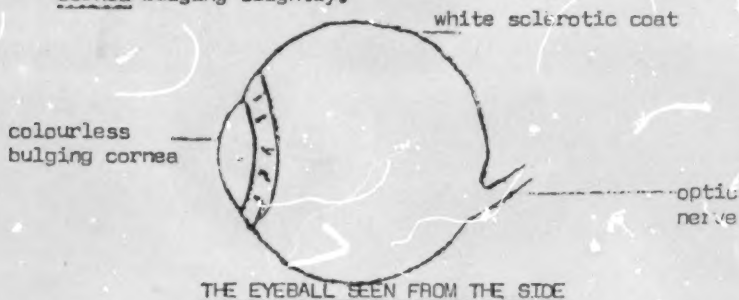
You will need:

a pair of scissors
forceps
scalpel
pins.

P

1. Using the scissors and the razor blade (or scalpel) trim off the eyelids, any remaining fatty tissue and the muscles, so as to bare the tough, outer white SCLEROTIC COAT made of fibrous cartilage. This outer coat gives shape to the eyeball and protects the softer inner tissues.
2. Be careful not to cut the optic nerve - a white string-like structure about 0.5 cm in diameter which is attached at the back of the eyeball.

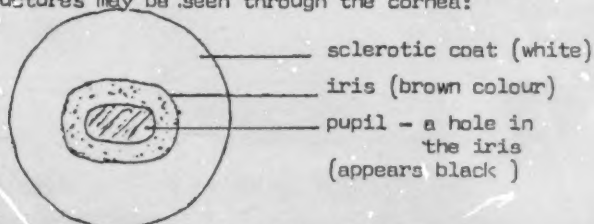
3. The sclerotic coat is a continuous opaque white layer over the whole eye except in the front of the eyeball where it forms a colourless transparent window called the CORNEA. Hold the eyeball so that you are looking at it from the side and you will see the colourless transparent cornea bulging slightly.



The transparent cornea permits light to enter the eyeball. Sometimes as a person gets older opaque patches develop in the cornea. We say that the person has a CATARACT in the eye, and it prevents them from seeing clearly.

Note: The cornea may go opaque when the animal dies and it is certainly opaque if the eye has been preserved.

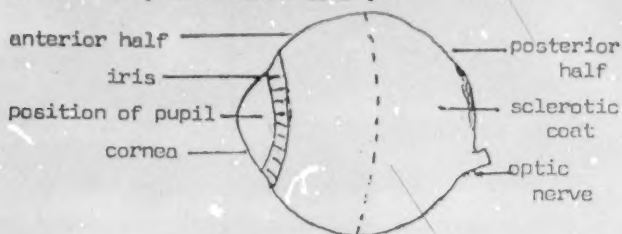
4. Look at the eyeball from the front, two more structures may be seen through the cornea:



a) Underneath the cornea you will see a brown coloured ring called the IRIS. This controls the amount of light entering the eye. You will learn more about the action of the iris in your next lesson.

b) This iris surrounds a hole called the PUPIL. This hole allows the light to enter the eyeball. Because the inside lining of the eye is black it reflects no light, so the pupil looks black.

5. Next cut open the eye following the path indicated by the broken line :



Begin the cut by piercing the tough sclerotic coat with the razor blade (or point of a sharp scalpel.) Several attempts may be necessary to penetrate the tough fibrous tissue of the outer coat.

Next, insert the blade of the scissors into the first cut and carefully cut around the eyeball as shown in the diagram. (If you have no scissors, you will have to use the razor blade to cut the eyeball open - take care!)

Note: While cutting the eye, hold it firmly, but do not squeeze. Support both halves of the eye so that the jelly-like material in the eye does not run out.

6. When the cut is complete right around the eyeball, squeeze the back half of the eye to remove the jelly-like material from the posterior part of the eye - this is called the VITREOUS HUMOUR. The jelly-like material helps to maintain the shape of the eye and being transparent allows light to pass through it.
7. Examine the now empty posterior half of the eyeball. Note that the wall has three layers or coats. Use your fingernail (or the end of the razor blade or tip of the scalpel) to separate the thin, pale, loose tissue of the innermost light-sensitive layer - the RETINA, from the middle, black-pigmented layer - the CHOROID. Nerve fibres from the light receptor cells of the retina can usually be seen converging to one point. It is possible to separate the retina from the choroid except in this one region.

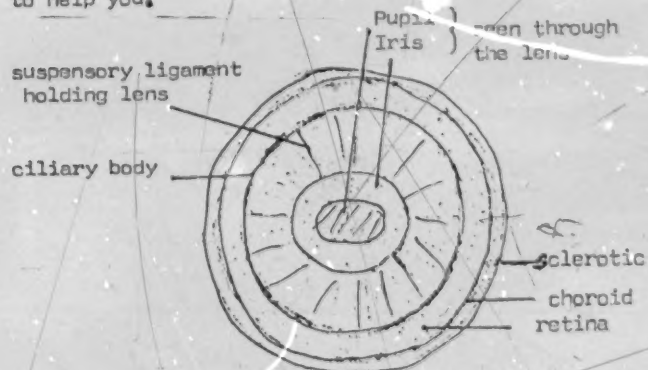
Turn the empty posterior half eyeball over and note what originates at this region where the retina and choroid are joined - yes, it is the optic nerve. Look at the inside again - and compare your specimen with the diagram below.



TO SHOW THE INSIDE APPEARANCE OF THE POSTERIOR HALF OF THE EYE

The point where the optic nerve leaves is called the BLIND SPOT - for in this region there are no cells sensitive to light.

- a. Now remove the jelly-like VITREOUS HUMOUR from the front half, of the eye - take care because the lens usually comes out as well. Once the vitreous humour is out, identify the structures you can see, using the diagram below to help you.



INTERNAL VIEW OF THE ANTERIOR HALF OF THE EYEBALL

Look inside the front half of the eye and note that the LENS is surrounded by a wide circular black band showing radially arranged ridges. This is the ring-like CILIARY BODY (or CILIARY MUSCLE) which is an extension of the choroid.

The actual connection between the lens and the ring-like ciliary body is made by the SUSPENSORY LIGAMENT - this is a fine circular membrane through which run radially striated fibres.

9. If the lens remained in position in the front half of the eye (ie: did not come away attached to the vitreous humour) now carefully separate the lens from the surrounding ligaments and lift it out.

Do you see a clear liquid escaping from the eye now?

This transparent fluid is called AQUEOUS HUMOUR, it fills the front chamber between the lens and the cornea.

The best way to see the IRIS and the PUPIL is to put your finger into the eyeball and look at it from the front through the cornea.

Note the rectangular shape of the pupil of the ox eye and then look at the eye of a fellow student - the shape of the pupil of the human eye is different.

10. Now examine the LENS.

Note the following:

it is quite firm to touch

it is transparent (if the eye is fresh, it goes opaque in preserved eyes)

it is circular and biconvex

From above



it is 'flatter' at the front than the back.

front



back

from side

Next, lay the lens on a flat surface.

compress it slightly with your finger. Then lift your finger to relax the pressure and watch the lens return to its original shape.

This ability of the lens to change in thickness is very important in the focusing of light rays in the eye.

If the lens you have removed from the ox eye is still transparent (and not too badly damaged), place it on a sheet of paper over a few printed letters.

Note how the lens magnifies the size of the printed letters.



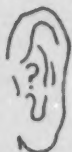
ACTIVITY 5 : Investigating the distribution of rods and cones in the retina. Page 25

Apart from using pieces of chalk, your pupils can use other things such as pencils and pens.



ACTIVITY 6 : Finding out if there is an area of the retina without rods and cones. Page 26

In case some pupils have lost their cardboard paper with X's they can make some on another piece of paper as long as the distance is about the same.



DISCUSSION.

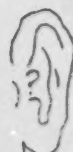
Page 26

The right X disappears as children move the cards nearer their eyes. This is so because the movement of the card changes the position of the light on the retina. When the right X can no longer be seen, the light from this X falls on the blind spot which is not sensitive to light.



ACTIVITY 7 : Making pictures with lenses. Page 27.

Apart from the use of the lenses from the kits, pupils can also use hand lenses, if they are available (or eye pieces of bioviewers if they are the type that can unscrew).



DISCUSSION

Page 27

Pupils should notice that the picture (image) is very clear only when the lens is at a certain distance from the white paper.

The white papers could be even the back of their Study Guides. The pupils will also observe that the image is upside down (inverted)

MODEL OF THE EYE

Page 30

Show your pupils each lens and it will be used.

Each group should have:

- 2 half convex lenses (type 1) from the light source box
- 1 half convex lens (type 2) from the eye kit (in battery box)
- 1 type 3 concave lens from the eye kit (in battery box)
- 2 half-convex lenses of type 4 (in battery box).

DISCUSSION page 32

Your pupils should see that unlike in the model:

- (a) The actual eyeball is spherical (like a ball).
- (b) In the eye light is refracted by (In the actual eye):
the cornea, the aqueous humour, the lens and the vitreous humour.
In the model the lens is the only structure refracting light.
- (c) In the actual eye, the thickness of the lens can be changed by the action of muscles. In the model the lens thickness remains the same.

EXERCISE 4

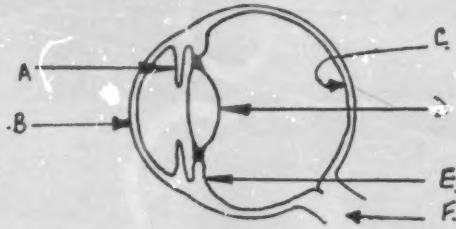
page 32

1. In the diagram below M and N show the appearance of a human eye.



- (a) What change in the surroundings would cause the appearance of the eye to alter from that shown in M to that shown in N?
- (b) Which muscles in the eyes contract to cause this alteration?

- 2 The diagram below shows the human eye (cut through)



Copy and complete the table below which is based on the diagram of the eye above.

Part	Name of Part	Function of Part
A		
B		
C		
D		
E		
F		

ANSWERS TO EXERCISE 4

1. (a) Change from bright light to dull light.
 (b) Longitudinal muscles.

Name of Part	Function of Part
A iris	alters size of pupil)
B cornea	refracts light
C retina	sensitive to light/image formed here
D lens	refracts light
E muscle	change lens thickness
F optic nerve	carry messages to the brain.

ACTIVITY 8: Two eyes are better than one

page 33

Instead of two sharpened pencils, pupils can use other similar objects like ball point pens.

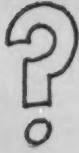
One should discover that it is easier to use both eyes than to use one.

ACTIVITY 9: Two eyes are better than one

page 34

Instead of using a piece of chalk, pupils can use other similar objects.

The main idea in this activity is that the left eye sees more on the left and the right eye sees more on the right. This gives wider vision.



ANSWERS TO HOW MUCH DO YOU KNOW?

page 35/36

1. (a) energy.
(b) reflected.
(c) reflected.
(d) refraction.
2. (a) Convex/converging.
(b) Notice that this sentence should just be copied like that as notes. Do not award marks for copying.
(c) colour or intensity.
(d) Retina.
(e) Muscles.
(f) Short-sight.
(g) Convex/converging, concave/diverging.

N.B. The first ____ is missing in 2g

EXERCISE 5



1. Fig. 1 represents two rays of light from a near object entering an eye which is unable to focus them.

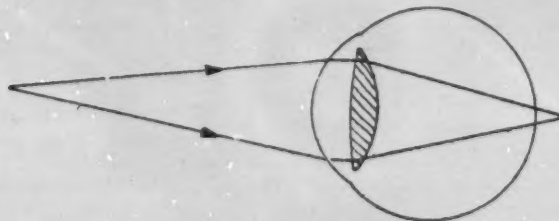
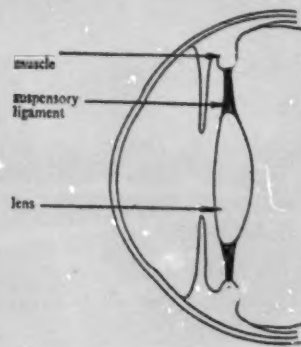


Fig. 1

- (a) What is the name given to the defect of vision illustrated by the diagram?
- (b) Sketch the diagram and add to the diagram to show a lens which can be used to correct this defect and draw the rays of light from the near object coming to a corrected position on the retina.

2. Fig. 2 shows part of the structure of mammalian eye.

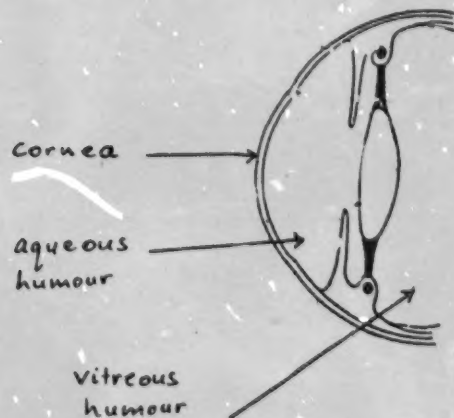


- (a) Sketch the diagram above and label
 (i) the cornea
 (ii) vitreous humour
 (iii) aqueous humour.
 (b) Explain how the eye muscle makes the lens thinner.

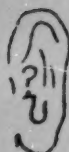
ANSWERS TO EXERCISE 5

1. (a) The defect is long sight.
 (b) Correction of long sight - see page 29 or Study Guide.

2. (a)



- (b) Contraction of the radial muscle of the eye causes the lens to stretch and become thin.



DISCUSSION

page 37

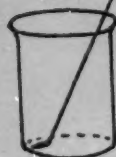
The class may come up with a variety of ideas e.g. the importance of hearing music, hearing the teacher while he is teaching, on coming things like wild animals which may be dangerous. The important thing is that we use our ears for hearing sounds of all kinds. This enables us to collect information about our surroundings. For example we hear the approaching things like a car.



EXPERIMENT 8: How is sound produced?

page 37

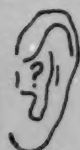
The main point to establish is that sound carries from vibrating objects.



EXPERIMENT 9: Frequency, sound and length of vibrating objects

page 39

The hand at A must be firm on the ruler.



DISCUSSION

Pupils should discover that when the length of the ruler used becomes shorter, the frequency increases.

When the frequency is high the sound produced is also high.



EXPERIMENT 10: Frequency, tension and sound.

page 40

Instead of a string your pupils can also use a twine if it is available.

The purpose of the tin is to magnify (make loud) the sound produced by the vibrating string.

N.B. YOU MUST NOT USE YOUR BOILING TINS FOR THIS EXPERIMENT.

You will need them for a lot of other purposes than for this experiment.

You can ask your pupils to bring a tin each. You then should safely keep these tins for further use.

Your pupils should discover that as the tension in the string increases, the frequency also increases and that the sound becomes high.

N.B. There is an error. This experiment continues on page 42.

Your pupils need an elastic band as well.

P



EXPERIMENT 11: Can sound travel through a solid?

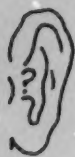
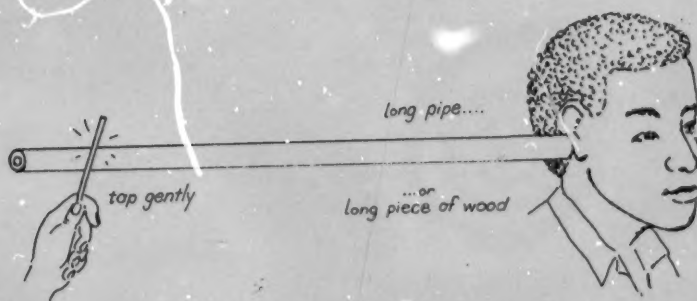
page 41

N.B. No need for an elastic band.

The tins used in the previous experiment are useful here but this time you need two of them per group.

Emphasise that the third pupil should touch the string lightly. This pupil will feel the movement of sound energy through the string. Of course this is not the only way of showing that sound travels through solids. Pupils may even find it difficult to accept that a string is a solid.

You can use an arrangement shown below.



DISCUSSION

There are two pieces of evidence from the experiment to suggest that sound travels through solids. Firstly the pupil listening can hear the sound, secondly the pupil touching can feel the vibrating movement of sound energy.

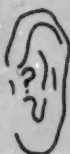
ANSWERS TO HOW MUCH DO YOU KNOW?

page 42

1. Vibrating things.
2. Frequency.
3. Shorter.
4. Increasing.
5. Pupils should copy this as important information in their books. Do not award marks for it.
6. High.

SOUND INSTRUMENTS

It would be very useful if you or the pupils were able to bring some of these sound instruments to class.

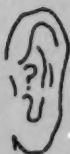


DISCUSSION

top of page 44

The ear symbol there warns the teacher that there is potential room for questions to be discussed. One possible area of discussion is that your pupils know that big drums produce low sounds. They may ask you to explain this. Tell your pupils this area will be treated in experiment 12.

It is possible pupils may ask you about sound instruments which are not in this unit. Try your best to answer. However, if you are not sure there is no harm in telling your pupils that you will find out. Then write to us or ask other people who might know.



DISCUSSION

bottom of page 44

Pupils should see from the diagram the pieces of metal are of different lengths. You may ask your pupils which pieces of metal give high sound.



EXPERIMENT 12: What is happening to the sound when the air column becomes shorter? page 45

Your pupils should discover that as the volume of air in the bottle becomes less, the sound becomes high. It is in fact the vibration of the column of air that is giving the sound. As your pupils can see in the diagram of marimba on page 45, the different vessels contain different columns of air, thus achieving different sounds. In the drums discussed earlier, apart from changing the tension in the skin, different sounds can be made by using different sizes of drums.

ANSWERS TO HOW MUCH DO YOU KNOW?

page 47

1. Air.
2. Slow, fast
3. Vibrations.
4. Short.
5. Tall.
6. Pupils should copy this extra information.

PARTS OF THE EAR AND THEIR FUNCTIONS

page 49

Notice that the inner ear was left out by mistake. On page 49 under "Middle" ear, there is enough space for your pupils to write in PENCIL the following paragraph.

Inner ear: Consists of a coiled cochlea.

The nerves in the cochlea pick up the energy and send it to the brain.

The sound is interpreted in the brain.

ACTIVITY 11: Magnification of sound by the small bones in the ear.

page 49

P

N.B. Tell your pupils to bring rulers to this lesson. Notice that the point of contact is at the edge of the desk/table or even bench.

PATH OF SOUND ENERGY IN EAR

page 51

This is a very important section in the study of the ear. You will find it an advantage if your pupils copied it in their notebooks together with a simplified diagram of the ear.

ACTIVITY 13: Sense of balance and your head.

page 52

The pupils should not rotate their heads too often as the dizziness may cause them to fall and hurt themselves.

MODEL OF THE SEMI-CIRCULAR CANALS

page 54

P

You need a plastic tubing of external diameter of approximately 8 mm. A small cardboard box e.g. your glucose powder box. Stickistuff and 3 pins.

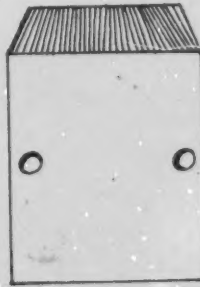
Continue to Page 33.

1. Cut 3 plastic tube pieces each approximately 18 cm long.



Face A

2. Make two holes on one face of the paper box.
Make the holes as shown above on Face A.



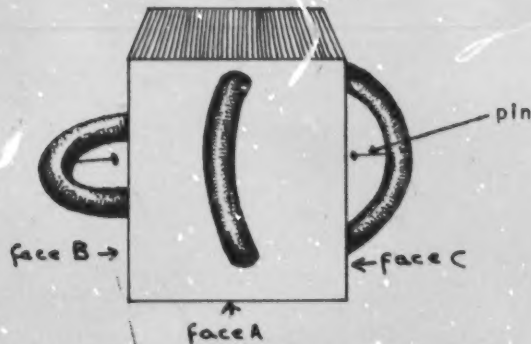
Face B

3. Make another two holes as shown on Face B.



Face C

4. Make another two holes on Face C (face opposite B).
These holes must be made in the same way as those on Face A.



5. Close one end of each tube using stickistuff.
Put a few grains of sand or sugar into each tube and then close the other end with stickistuff.
6. Now push ends of the plastic tubing pieces into the holes as shown in the diagram.
7. Push a pin through each tube.
8. Tell the pupils as you show them that:
 - (a) This is the way the semi-circular canals are arranged.
 - (b) The sand or sugar grains represent the liquid inside the canals. The pin represents the nerve endings in the canals. These pick up the message and send it to the brain.

Turn the box over to show how the sand grains always move in one canal whichever way the head is leaned. Pass the model around.

ANSWERS TO HOW MUCH DO YOU KNOW?

page 54

?

1. Sound.
2. Outer ear, inner ear and middle ear.
3. Auditory canal.
4. Small bones.
5. Oval.
6. Cochlea.
7. Auditory.
8. (a) Balance.
(b) fluids and nerve endings.

ANSWERS TO EXERCISE 6

page 55

- (a) A - ear drum.
B - small bones.
C - semi-circular canals.
- (b) The ear drum receives sound and vibrations from the outer ear.
The small bones magnify vibrations and pass them onto the oval window.
The semi-circular canals help to maintain balance.
- (c) You may damage your eardrum and fail to hear (cause deafness).
- (d) If one of them were to be damaged, you will still have one.

THE NERVOUS SYSTEM

page 56

P

By the first lesson of this section you will need to have dissected a rat and make sure that both the brain and the spinal cord are exposed.

I have included here instructions on the dissection as they appear in Unit E1 T.G. since this is where you might want to start before you proceed to the dissection of the brain and spinal cord. You do not have to dissect the body of the rat, but it would be a good idea to do so briefly as a revision exercise especially of the gut and kidneys. Then proceed to the skull and brain. The instructions to the dissection of the brain and spinal cord are found on page 42 in this Teacher's Guide.

DISSECTION OF A RAT

Do not attempt this dissection unless you have obtained a properly bred rat.



NOTE: Wild rats must not be used as they may carry a dangerous disease.

KILLING THE RAT OR RABBIT

Killing: It is essential that the animal is killed **OUT OF SIGHT OF THE PUPILS.** The animal's neck can be broken by holding the shoulders and pulling the head sharply up and out.

While the animal is still warm pin it out on its back (using pins or nails to secure the hands and feet) on a piece of wood.

Note the external sex organs of the animals as shown in the following diagrams A and B:

Ways of telling the sex of the animal before you cut it open:

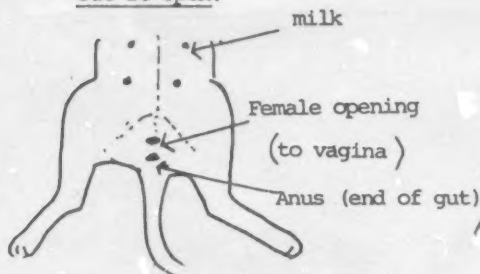


Diagram A

Female - external characteristics

Cutting lines:

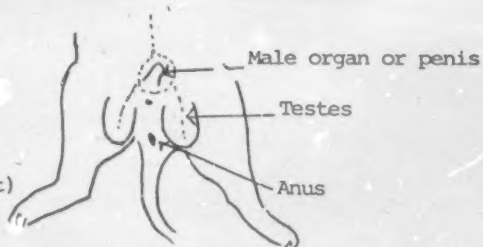


Diagram B

Male - external characteristics

Cutting lines

It may well be difficult to sex young specimens because the sex organs are not well developed. The distance from the male opening to the anus is much further than the distance between the female opening and the anus.

The dissection:

You will need:

forceps
scalpel
pins or nails

scissors

Lift the furry skin between your fingers and make a slit with your scissors. You will now know whether you have a male or female rat. We have shown lines in diagram A (of the female rat) and B (of the male rat) to show you where you should cut. Put the point of the scissors into the skin and cut, being careful to hold the scissors almost horizontal. It helps to keep your elbows close to your body while you work. If you poke the scissors too deep into the rat's body you may accidentally cut and damage the gut which will make a horrible smell.





Fold back the skin Underneath
 you will see white muscle, which is the body wall. Cut
 this carefully in the same way as you did the skin and
 pin it back to the wood. You will now see the rib cage (bones)
 between the 'arms'. Below this is the dark red liver.
 The rest of the opening will be filled with the long
 coiled up gut.

If the rat is a pregnant female you may see the uterus at once, filled with embryos.

The next step in the dissection will be to remove the gut.

The gut is held in place by a thin tissue, like a piece of plastic bag. You will need to cut the gut away from this tissue. Hold the gut tube in your fingers, or use forceps. Separate it from the tissue with your scissors or a scalpel.

Pull all the gut out of the rat's body and lay on one side to show the length to the pupils.

Cut off as much of the gut as possible and remove it.

You will now have an almost empty body.

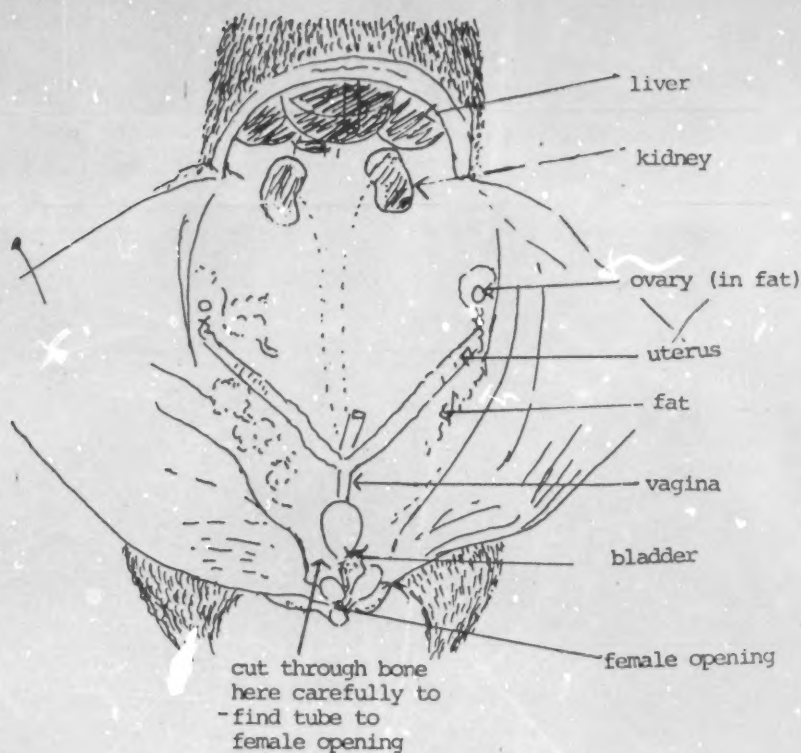
The liver will still be present. Lift up the liver and look underneath it. You will see two kidney organs shaped like beans, dark in colour, and point them out to the pupils.

Cut open the rib cage (bony area between the arms) by cutting through the ribs on one side of the centre bone. Inside you will find the pale pink spongy lungs and dark red heart between. Point these out to the pupils as further examples of organs.

Between the back legs you will find a small bag of liquid - this is the bladder. Be careful not to cut it.

If you have a female rat, follow the instructions for female rat dissection while looking at picture 3 .

If you have a male rat, follow the instructions for a male rat dissection while looking at picture 4 .

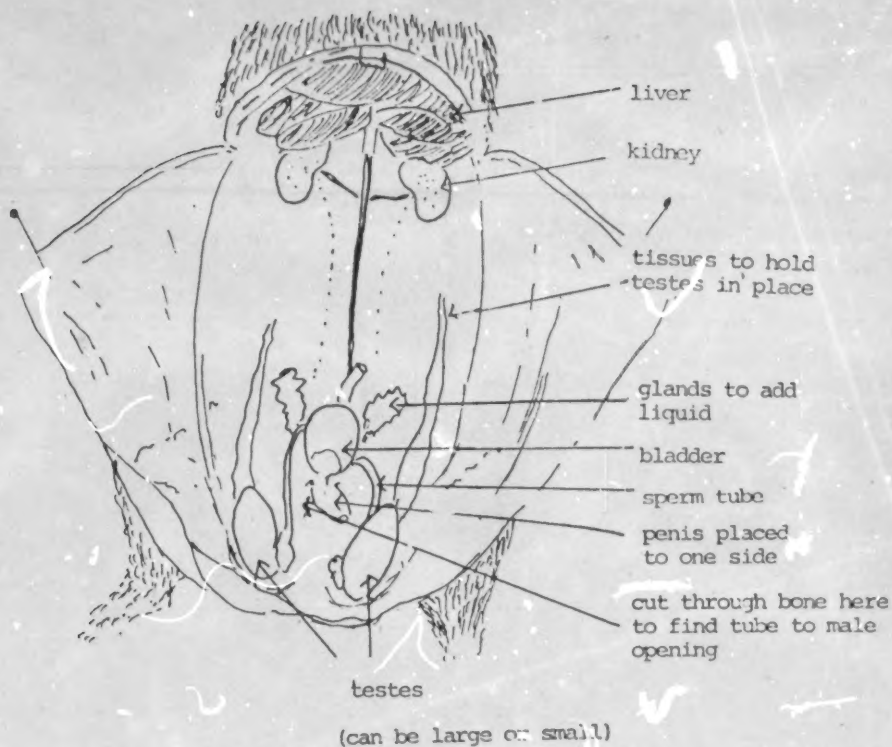


picture 3

Special notes on the female dissection:

If your rat is pregnant, take care not to mix up the gut with the uterus. The uterus will have lumps in it (see pupils' book page 32).

A non-pregnant rat's uterus is quite small. It may have white lumps of fat hanging on it. You will have to take care to find the ovaries which are small and in fat above the uterus. The egg tube is a small coiled tube. The vagina is found where the two arms of the uterus join near the bladder. Carefully cut the bone (see picture and find where the tube from the bladder and vagina lead to the female opening.



Special notes on male dissection:

Cut open the testes bag. Inside you will find two round organs which are the testes. These have long white tissue going up into the body which hold the testes in place. The sperm tubes are thinner tubes and go behind the bladder. Two wrinkled organs just above the bladder are for making the liquid to add to the sperm.

Using your scissors, carefully cut the bone between the legs where shown in the picture, and find where the tube from the bladder leads to the penis.

EXPOSING THE BRAIN AND SPINAL CORD

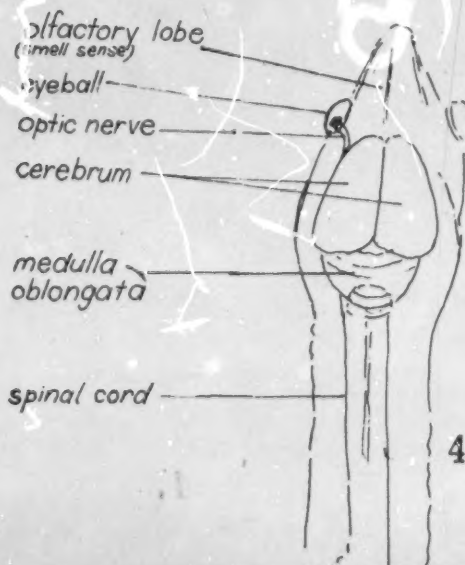
P

1. Continue cutting the skin to the neck.
2. Remove the skin on the head and around the neck and front feet.
3. Cut through the chest and remove the ribs.
4. Remove the meat in the head and the neck so that you are left with bones.



5. Scratch part of the skull with a blade. You will see sutures (joints) as shown above.
6. Push a knife or blade through the sutures and bend it to open the bones.
7. Using a pair of scissors open the backbone to the neck to see part of the spinal cord as shown below.

Parts of the Brain.



It is advisable to have this dissection ready before the lesson. If you dissect a day in advance or if you want to use it in the near future, you can preserve the dissection immersed in methylated spirits in one of your jam jars which must be tightly closed to prevent evaporation of the spirit.

1. Show your pupils the various parts as shown in the diagram
2. Let them draw and label what they can see.
3. Put the following on the board and allow pupils to copy it in their notebooks.

Part of Brain

Function

Cerebrum

Responsible for seeing, hearing, thinking.

Cerebellum

Responsible for voluntary actions
(actions under your conscious control).

Medulla oblongata

Responsible for involuntary actions
(actions not under your conscious control).

Ask the pupils: 'What is the advantage of having both the spinal cord and the brain surrounded by strong bones?'

Answer: Since both are delicate and so important to our lives, the strong bones are good for protection.

ACTIVITY 14: Central nervous system.

page 56



Children will need:

a sharp pencil

rubber

biolviewer

biolset and strip ZS/4.

It is important to look at the slides before the lesson so that you are aware of what children are expected to see. You should move from one group to another as they do the activity.

ANSWERS TO QUESTIONS ON ACTIVITY 14

page 56



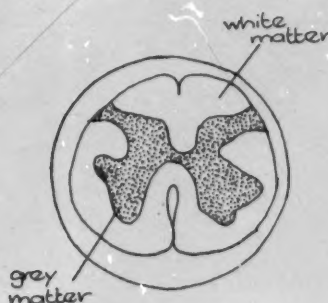
1. (a) Two main parts of the central nervous system are the spinal cord and the brain.
- (b) Two main functions of the central nervous system:
It interprets (gives meaning to) messages coming from various sense organs. It also organises other activities of the body such as growing, breathing, sleeping and thinking.

ACTIVITY 15

page 56

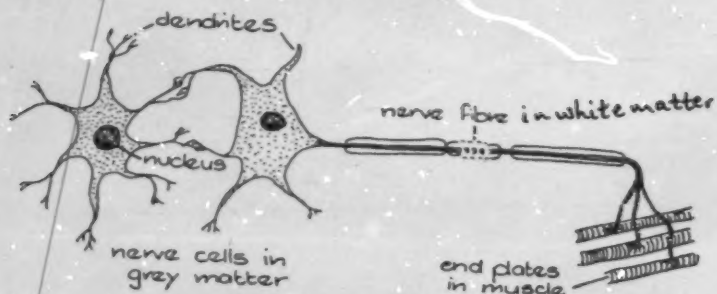


1. (a) Pupils should come up with a diagram similar to the one below.



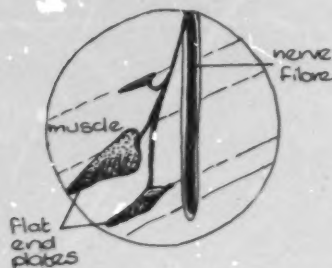
- (b) (i) Grey matter is made up of nerve cells.
(ii) White matter is made up of nerve fibres.
2. (a) Two functions of the spinal cord:
It relays (sends) messages from the sense organs to the brain. The nerve cells in the spinal cord also send a message straight to a muscle or gland.
- (b) Reflex action - an automatic and unconscious response to a stimulus.

3. (a) Diagram as shown below.



- (b) Functions of fine branches sticking out. They transmit (pass on) messages from one cell to another.

4. (a) Diagram as shown below.



- (b) The connection!

The sense organs send messages to the central nervous system. In turn the central nervous system sends a message to the plate. When stimulated, the plate causes the muscle to contract, so bringing about a movement of the body.



ACTIVITY 16: Knee jerk.

page 59

It is important that the person sitting down should be relaxed, otherwise the reflex action will not take place.

The diagram at the bottom of page 59 is part of the answer to the question posed and explained on page 60.



ACTIVITY 17: Swallowing

page 60

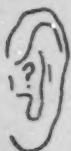
Pupils should feel the movement of the throat as the saliva is swallowed. They should also discover that it is difficult, if not impossible to stop movement once it starts.



ACTIVITY 18: Blinking

page 61

Once again blinking takes place without conscious control.



DISCUSSION

Of course, examples of reflex actions are quite numerous. Here are a few more examples that your pupils might come up with:

- coughing
- sneezing
- salivating when they smell delicious food
- screaming when frightened.
- yawning.



ACTIVITY 19: Reaction time.

page 63

Reaction Time

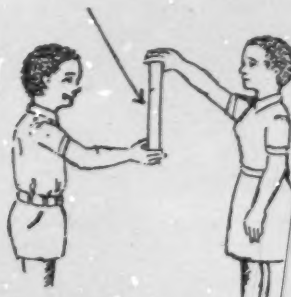
0,05 s
0,10 s
0,15 s
0,20 s
0,25 s

Distance

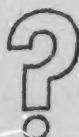
12 mm
44 mm
110 mm
196 mm
306 mm

Do all people have the same reaction times?
Do you think your reaction time is the same when you are feeling sleepy?

You will need: a ruler



Some of your pupils may be lucky enough to get the distances that give the times exactly as they are shown in the table. For instance, a pupil can get a distance of 110 mm, which enables him to read his reaction time of 0,15 s as shown in the table. However, a good number of your pupils will get distances that give them times between those shown in the table. For example, the distance might be 40 mm, this means that the reaction time lies between 0,05 s and 0,10 s. They should express their reaction times like that and should not attempt to approximate since the relationship between distance and time is non-linear. Remember knowing what and how to measure the reaction time is more important than accuracy.



ANSWERS TO HOW MUCH DO YOU KNOW?

page 63

1. Nervous.
2. Nerve.
3. Messages/impulses.
4. Cerebellum.

page 63

Exercise 7

1. The diagram below shows a vertical section through the left side of a human brain.



- (a) Give the names of the three structures: A, B and C.
- (b) What is the function of B?
- (c) Which of these structures is concerned with conscious thinking?

2. Which of the following are examples of reflex action:
 - (a) sneezing.
 - (b) walking.
 - (c) yawning.
 - (d) heartbeat.
 - (e) breathing.
 - (f) singing.
 - (g) Sweating.
3. Which of the above are examples of :
 - (a) voluntary actions.
 - (b) involuntary actions.
4. Both heartbeating and seeing are controlled by the brain. Explain why heart-beating could be normal and yet one is blind. i.e. why can the brain work well for heartbeat and not for seeing.

ANSWERS TO EXERCISE 7

page 63

1. (a) A - cerebrum.
B - cerebellum.
C - medulla oblongata.
(b) Responsible for involuntary actions.
(c) A - cerebrum is concerned with conscious thinking.
2. Sneezing.
Yawning.
3. (a) Walking, singing.
(b) Sneezing, yawning, heartbeat, breathing, sweating.
4. Heartbeat is controlled by the medulla oblongata while seeing is controlled by the cerebrum, i.e. the two processes are not controlled by the same part of the brain.

SUMMARY

page 64

Ask pupils to write this in their exercise books.